

Radioactivity in surface waters near the old uranium mines of Quarta-Feira Valley, Portugal

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Abstract

In the Quarta-Feira valley, near Sabugal, four uranium deposits were extracted in the 1950s-70s by open pit and underground works. The uranium ore was partially processed at two of these mine sites in the valley, Bica Mine and Vale de Arca Mine, and the milling tailings disposed off nearby. In the Bica Mine, sulphuric acid was used in the underground works to extract *in situ* low grade uranium ores. Mine water drainage, including acid mine waters and surface runoff from the mining and milling tailings, flow into the Valverdinho and Quarta-Feira streams, that are tributaries to the Zêzere River a major river with water being used for human consumption and irrigation. Uranium series radionuclides were determined in the dissolved and particulate phases of water samples collected in this river system, in the mining and milling tailings, in agriculture soils, and in agriculture products in order to assess environmental radioactivity. In Vale de Arca mine waste exposed to weathering, the activity concentrations of ^{238}U , ^{226}Ra and ^{210}Pb attained 28×10^3 Bq/kg, 19×10^3 Bq/kg and 16×10^3 Bq/kg, respectively. These can be compared with radionuclide concentrations in soils of this region which contained 350, 620 and 370 Bq/kg of ^{238}U , ^{226}Ra , and ^{210}Pb , respectively. The radioactivity in stream water and sediments decreased downstream with increasing distance to the mines, and in the Zêzere River concentrations were already at naturally-occurring background levels, and below the maximum allowed radioactivity concentrations in drinking water. Near the mines, the enhancement of radioactivity was observed in soils, stream sediments, and in the water of some irrigation wells, herein attaining, for example, 49 mBq/L in the soluble phase and 12.8×10^3 Bq/kg of ^{238}U in the particulate matter, much above the natural background. Seepage of the acid mine water from the underground Bica Mine seems to be the source of this enhanced radioactivity levels. Vegetables grown in agriculture plots irrigated with this water displayed enhanced radioactivity levels as well. As the

mine water from Bica Mine is acid, with pH around 4, and contains high concentrations of radionuclides, the continued treatment for pH correction and removal of radionuclides before discharge into the streams should be continued. Remediation measures for milling waste tailings, contaminated mine waters, and sludge from mine water treatment aiming at enhanced environmental protection and radiological protection of the population are discussed.